PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04H 1/00 — A1

(11) International Publication Number: WO 97/17776

(43) International Publication Date: 15 May 1997 (15.05.97)

(21) International Application Number: PCT/FI96/00595

(22) International Filing Date: 5 November 1996 (05.11.96)

(30) Priority Data:
955357 7 November 1995 (07.11.95) FI

(71) Applicant *(for all designated States except US)*: OY NOKIA AB [FI/FI]; Eteläesplanadi 12, FIN-00130 Helsinki (FI).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: SALOMÄKI, Ari [FI/FI]; Ojavainionkatu 10 D 28, FIN-33710 Tampere (FI). KASSLIN, Mika [FI/FI]; Torkkelinkatu 17 A 18, FIN-00500 Helsinki (FI). PEHKONEN, Jukka [FI/FI]; Uudenkyläntie 1 B 6, FIN-36720 Aitoo (FI).

(74) Agent: LUOTO, Kristian; Nokia Research Center, PL 45, FIN-00211 Helsinki (FI).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

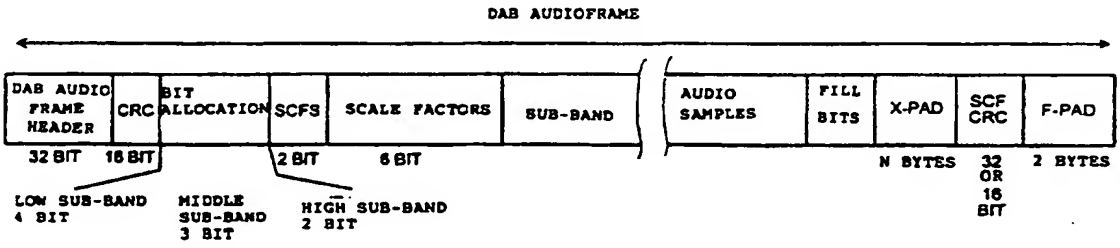
Published

With international search report.

Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

In English translation (filed in Finnish).

(54) Title: TRANSPORT OF AUDIO IN A DIGITAL BROADCASTING SYSTEM



(57) Abstract

In a digital broadcasting system (DAB), audio is transmitted as a continuous stream in audio frames. According to the invention, this is achieved by transmitting exactly one audio frame in the data field of each data group. Audio can be transferred as a file, in which case a given number of successive audio frames make up an audio file and the audio file is transferred in accordance with the file transfer protocol of the system. In this case, the transfer speed may vary. Audio can be transferred in packet mode as a continuous stream and the audio frames are transferred at the same speed by forming successive data groups from audio frames coming as a stream and by selecting the transfer speed of the data packets so that the transfer speed of an audio frame assigned to the data group is the same as the transfer speed of an audio frame transmitted as a continuous stream.

Best Available Copy

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AM	Armenia
AT	Austria
AU	Australia
BB	Barbados
BE	Belgium
BF	Burkina Faso
BG	Bulgaria
BJ	Benin
BR	Brazil
BY	Belarus
CA	Canada
CF	Central African Republic
CG	Congo
CH	Switzerland
CI	Côte d'Ivoire
CM	Cameroon
CN	China
CS	Czechoslovakia
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France
GA	Gabon
GB	United Kingdom
GE	Georgia
GN	Guinea
GR	Greece
HU	Hungary
IE	Ireland
IT	Italy
JP	Japan
KE	Kenya
KG	Kyrgystan
KP	Democratic People's Republic of Korea
KR	Republic of Korea
KZ	Kazakhstan
LI	Liechtenstein
LK	Sri Lanka
LR	Liberia
LT	Lithuania
LU	Luxembourg
LV	Latvia
MC	Monaco
MD	Republic of Moldova
MG	Madagascar
ML	Mali
MN	Mongolia
MR	Mauritania
MW	Malawi
MX	Mexico
NE	Niger
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RO	Romania
RU	Russian Federation
SD	Sudan
SE	Sweden
SG	Singapore
SI	Slovenia
SK	Slovakia
SN	Senegal
SZ	Swaziland
TD	Chad
TG	Togo
TJ	Tajikistan
TT	Trinidad and Tobago
UA	Ukraine
UG	Uganda
US	United States of America
UZ	Uzbekistan
VN	Viet Nam

TRANSPORT OF AUDIO IN A DIGITAL BROADCASTING SYSTEM

The present invention relates to audio transport in a digital broadcasting system in which services can be transported as a continuous stream or in data packets.

The Digital Audio Broadcasting (DAB) system, which has been developed to allow an efficient utilization of frequency bands, uses a completely digital transmission path. The system is designed to replace the analogue broadcasting system commonly used at present, which is based on the use of frequency modulation. DAB defines a digital radio channel based on multiple carriers, which is applicable for the transmission of both audio and data services. A completely digital transmission channel may be either a continuous data stream channel or a packet channel. Packet transmission is more flexible and allows easier transmission of data units of finite length. The DAB system is presented in ETSI (European Telecommunication Standards Institute) standard 300 401, February, 1995.

From the user's point of view, the highest level of abstraction in the DAB system is called ensemble, Fig. 1. It contains all services existing in a given frequency band. A change from one ensemble to another is effected by tuning to a different frequency band, just as one changes channels in current FM radio reception. The ensemble is divided into services, exemplified in Fig. 1 by Alpha Radio 1, Beta Radio and Alpha Radio 2. In addition, there may be data services, although they are not shown in the figure. Each service is further divided into service components. A service component can be transported either via an audio channel or via a data channel. For comparison, let it be stated that FM radio contains only one service and one service component

(audio) in each channel. At the lowest level, the transmission frame, whose duration is 24 ms or 96 ms depending on the DAB mode, consists of three chronologically consecutive parts. The first part is a synchronizing channel, which contains no service information. The next part is a fast information channel FIC, which has a mode-specific fixed length. The last part is a main service channel MSC, which contains all the subchannels. The position, size and number of subchannels within the MSC may vary, but the size of the MSC is constant. The MSC contains a maximum of 63 different audio and/or data subchannels. The subchannels are numbered on the basis of a so-called sub-Channel Id from 0 to 62. Moreover, the MSC may contain an auxiliary information channel AIC, which has a fixed channel number 63. The AIC may contain the same type of information as the FIC. The MSC information is transmitted using time interleaving such that in DAB mode I the MSC part of the frame is divided into four parts and these are placed in successive transmission frames. These parts are known as CIF (Common Interleaved Frame), so the MSC part of the frame in mode I contains four CIFs. In other modes no interleaving is used, so the MSC is the same as the CIF.

At the transmitting end, besides audio services, the service supplier may also provide data services and e.g. multimedia services. From the audio information and data supplied by the service suppliers, the DAB operator produces a DAB transmission signal, which consists of successive transmission frames such as those presented in the lower part of Fig. 1.

In the receiver, the information channel FIC and the channel MSC containing the audio and data services are separated from each other from the transmission frame. The subchannels are separated and channel decoded

and then passed on for further processing. From the information in the received FIC channel, the user will know which services are included in the ensemble received and is thus able to select a desired service or services. By combining subchannel service components according to the application programme, it is possible to compose e.g. a desired multimedia service.

One advantage of the DAB system is that data capacity can be reserved for different service suppliers on a dynamic basis. The capacity may be 1.728 Mbit/s at most. The data is transmitted in packets as illustrated by Fig. 2, consisting of a header field, a data field and a checksum. The meanings of the fields are in accordance with the DAB standard. The packet header contains packet length data (Pkt Len), a continuity index (Cont Ind), first/last packet data (First/Last), an address (Pkt Address) identifying the service component, a command (Command) and the actual data field length (Data Len). The data field contains the actual data to be transmitted plus fill bits if required. At the end is the packet checksum (Pkt CRC).

By combining the data fields of packets in the receiver, a so-called data group is formed, Fig. 2B. The packets are formed at the transmitting end from the data group by simply cutting it into sections and placing each section into the data field of a data packet. Generally a data group consists of the data fields of a number of consecutive packets transmitted. In the simplest case, one packet is sufficient to form a data group.

The data group is formed as illustrated by Fig. 3. The meanings of the abbreviations of the data group header and session header fields are as indicated in the table below:

Data Group header		Session header	
EXT FL	extension flag	LAST FL	last
CRC FL	CRC flag	SEG NUM	segment number
SES FL	session flags	RFA	reserved for future applications
DG TYPE	data group type	LEN IND	length of next address field
CONT IND	continuity index	ADDR FIELD	end user's address
REP IND	repetition index		
EXT FIELD	extension field		

These header fields are followed by the actual data and the data group checksum DG CRC.

A continuous audio stream is transmitted in frames having a structure as illustrated by Fig. 4. At the transmitting end, 16-bit PCM coded audio samples coming at a frequency of 48 kHz are divided into sub-bands and the samples of the sub-bands are encoded into the audio frame by making use of the masking effect of the human ear so that the incoming bit rate 768 kbit/s is reduced e.g. in the case of a mono channel to a rate of about 100 kbit/s. The four-byte header of the frame contains information intended for the decoders in the receiver, such as synchronization data, bit rate data, and sampling frequency data. A bit allocation field coming after the checksum indicates how the bits are allocated to each one of the audio field sub-bands containing 36 coded samples and which bits have been removed from the samples in making use of the masking effect. A Scale Factor Selection Information field indicates how the group of audio samples has been scaled (normalized) in the decoder. After this there is a field that contains the audio bits proper. The information in it corresponds to 24 ms of audio. The field contains 36 encoded sub-band audio samples divided into twelve triplets, each of which contains 3 sub-band samples. Thus, four triplets

corresponds to 12 ms of audio. Next there are fill bits if the number of audio bits amounts to less than the audio field length. Finally there are an X-PAD and an F-PAD field, which transmit Programme Associated Data (PAD). This data is in synchronism with the audio of the frame. The PAD bytes of successive frames make up a so-called PAD channel.

The audio part of multimedia is proposed to be transmitted in audio frames, yet there may be certain reasons to transmit audio in packet mode as well. Packet mode transmission could in principle be applied e.g. to send audio files, which would first be stored in the memory of the receiver and then played back via the speakers at the appropriate time during the multimedia presentation. This type of audio transport has the advantage that the file can be transmitted at any bit rate, so the transport rate need not be the same as the fixed bit rate which is used in the transmission of audio frames or an audio stream and which has been assigned a number of allowed bit rate values in the DAB specification.

A disadvantage with this type of transmission is that the audio file has to be stored in memory if the transport rate is lower than the audio stream bit rate, or it needs to be buffered if the transport rate is higher than the audio stream bit rate. In the former case, playback cannot be started immediately upon reception of the file, whereas in the case of buffering, playback can be started immediately. However, the disadvantage is not a real one, because in most of the possible practical applications there is no need to transmit an audio file at the audio stream bit rate. The real problem is that the audio stream in audio frames cannot

be transmitted in packet mode because there is no mechanism for indicating the audio frame boundaries.

However, there are certain applications in which it is desirable to implement audio transfer in real time packet mode. Real time packet transmission here means that the bit rate is the same in the transmission of both the audio stream and the audio packets, and that it would be possible in some way to extract from the packets the same information that is contained in the audio frames. This principle could be applied e.g. to locate bit errors in audio frames by comparing the received audio frame with the checksum CRC of the received packets that carry the same audio information and with the checksum CRC of the data group formed from the packets. In this way, the audio samples in the audio frames would end up being covered by CRC checking. Using packets for this purpose would involve extra auxiliary signalling of audio, which might be acceptable as a temporary solution. If audio transmission is to be protected on a lasting basis and as efficiently as packet transmission is, it would of course be preferable to improve the error protection of the audio bits in audio frames directly.

Another possible application of real time transfer of audio packets is found in the case where audio is to be addressed to a given user group only. This application makes use of the fact that the packets contain an address. As shown in the table above, the session header contains a field reserved for the end user's address, ADDR FIELD. This could be utilized to direct audio information to a given group, allowing real time packet transmission to be used as an information channel for different user groups. The DAB specification also defines the transmission of announcements via the fast in-

formation channel FIC. The definition describes the interruption of an active broadcast-type service by an announcement, but the transmission profile for the announcement can only be defined by specifying the services to be interrupted. There is no way to address the announcement to a given user group only.

Therefore, the object of the present invention is to achieve audio transport in packet mode so as to allow both addressed audio transport and indication of audio frames in a packet stream.

This object is achieved in the manner described in the independent claim.

According to the first embodiment of the invention, audio is transmitted over a packet channel as a file. An audio frame is placed in the data field of a data group. Thus, one segment in the file transfer protocol corresponds to one audio frame. From the packets received through the channel, a data group is assembled in the normal manner, so the data field of the data group will contain a file segment, which in this case is an audio frame. To enable the audio frames obtained from the data field to be arranged in the correct chronological order in the receiver, a file transfer protocol needs to be used. Since the transfer can be performed at any speed, the frames have to be stored or buffered in the receiver prior to presentation.

According to the second embodiment, the audio frames are transmitted over a packet channel in the form of a continuous stream. An audio frame is placed in the data field of a data group. The transmission speed is exactly the same as the audio channel bit rate. In this case, individual data groups are transmitted at exactly the correct pace, so the transmission consists of an endless train of data groups. Therefore, no file trans-

fer protocol is needed. No buffering needs to be used, but the receiver presents the audio frames directly as it receives data groups from the packet channel.

The invention is illustrated by the attached drawings, in which

Fig. 1 presents a known DAB hierarchy,
Fig. 2a presents the structure of DAB packets,
Fig. 2b shows how a data group is formed from packets,
Fig. 3 presents the structure of a data group,
Fig. 4 presents a DAB audio frame, and
Fig. 5 illustrates the use of an IDG.

According to the invention, to allow the audio frame boundaries to be clearly indicated when audio information is transmitted in packet mode, one and only one audio frame in its entirety, including the PAD part, is assigned to each data group.

According to the first embodiment, the audio frames are transmitted as an audio file, in other words, the audio, which has a beginning, a duration and an end, constitutes one file. In accordance with the file transfer principle used in DAB, the file is divided into segments and each segment is placed in the data field of a data group. The protocol will be briefly described below. According to the invention, a segment is exactly equivalent to an audio frame. Since the audio is transmitted as a file, it is necessary to use a file transfer protocol to enable the receiver to arrange the data groups assembled from the packets into the correct sequence. The file transfer speed may be higher than, the same as or lower than the audio stream bit rate.

The file transfer protocol can be implemented according to the general basic principle proposed by the Eureka-147 project, in which each segment forms one data group. Successive segments of the file are numbered sequentially so that the first segment number in the session header is 0. The last segment of the file is indicated by a flag in the LAST field of the session header of the data group formed from it. The receiver receives the data packets and forms data groups out of them. If its checksum indicates that bit errors occurred during the transfer, the receiver picks up the data packets of the relevant data group from the retransmission of the file.

To enable the receiver to pick up the correct files from the packet stream transmitted and identify the file type in question so as to ensure proper file management, the Eureka-147 project includes a proposition that an additional special Information Data Group (IDG) be created. This is a file transfer descriptor, i.e. it provides the necessary information about the file it refers to and it is multiplexed with the file segments.

Fig. 5 illustrates the idea of the IDG in file transfer. One IDG is associated with only one file. It is placed at least at the beginning of the packet stream relating to the file, i.e. at the beginning of the file transfer, but IDGs can also be placed in the middle of the packet stream, in other words, the IDG may appear at any point during the file transfer or the IDG can be transmitted some time before the actual file transfer, so it can be used to announce a file transfer before it is started. In Fig. 5, files X, Y and Z are transferred and the IDGs referring to them are identified by corresponding letters. The important thing that can be accom-

plished by means of the IDG is contained in its data field, which is called the 'file descriptor'. The file descriptor can be used to give the receiver the required detailed information about the file to be transferred. The file descriptor includes a field containing so-called transfer parameters (T-parameters). A T-parameter called File Type declares the type of the file, so the application software of the receiver is able to decide which algorithm to use for file analysis and interpretation of its contents.

The applicant proposes that a new file type parameter called "DAB audio" be added to let the receiver know that the incoming file announced by the IDG is an audio file.

According to the DAB specification, the information about the services is transmitted over the fast information channel (FIC). It is used to announce the location and nature of the service components. A service description for each service is placed in a separate field, which contains a parameter field called service component description. One of the parameters is service component type and this parameter is set to File Transfer.

From the FIC channel information the receiver thus learns that a file is being transferred and from the IDG information that the file is an audio file. The receiver is therefore able to receive the file, decode the audio and present it. Depending on the file transfer speed, the receiver must either store the audio file or use buffering for it.

According to the second embodiment, the audio frames are transmitted in packet mode, yet as a continuous audio stream. The transfer speed is exactly the same as it would be if audio frames were used. At the trans-

mitting end, as audio frames are coming as a continuos stream, each audio frame is first assigned to a data group, then packets are formed from the data group and transmitted. The audio frame also contains the PAD. Thus, the transmission is not a file transfer procedure as in the first embodiment, so no file transfer protocol is needed. Therefore, no information data groups IDG are needed, either. An audio data group may never cross the CIF boundary, so the entire data group must be transferred in a single common interleaved frame CIF. In other words, the data group must be transferred in a single transmission frame. If repetition is used at the data group level, then the data group and all the repetitions of it must be transmitted in a single CIF, i.e. each repetition is transmitted in a single CIF.

When a data group is formed, a session header is not necessarily needed, but it is advisable to use it because it contains an address field ADDR FIELD, which is intended for the end user's address. By means of this address, an audio transmission can be addressed to a desired user group. If the session header is used, then the SEG NUM field is used as a counter that is incremented by one on every data group. This helps the receiver keep in synchronism, because if a data group fails to be transmitted or is defective, the playback is delayed by the duration of an audio frame. The flag in the LAST FL field is always zero because the transmission is a continuous audio stream, albeit in packet mode.

The data group can be interleaved with other packet mode service components in the same subchannel, but the data group must still fit into a single CIF. If a data group is interleaved with other service components carrying audio data groups in the same subchannel,

then all the data groups must be transmitted in a single CIF.

As in the case of the first embodiment, the applicant proposes that the service component type parameter "DAB Audio Stream" be sent in the service component description field in the fast information channel FIC.

It is obvious to a person skilled in the art that technological development permits many different ways of implementing the basic idea of the invention. The invention and its embodiments are thus not limited to the examples described above but may be varied within the framework of the claims.

Claims

1. Procedure for the transfer of audio in a digital broadcasting system, in which an audio programme transmitted as a continuous stream is transferred in the form of audio frames and in which, in packet mode, the information to be transmitted is assigned to the data field of a data group (DG) and the data group is divided into segments which are placed in the data fields of the data packets,

characterized in that the audio is transmitted in packet mode by placing the audio frame in the data field of the data group.

2. Procedure as defined in claim 1, **characterized** in that a certain number of successive audio frames make up an audio file and the audio file is transferred in accordance with the communication protocol of the system.

3. Procedure as defined in claim 2, **characterized** in that the transfer rate of the audio frames can be freely selected within the limits of the packet transfer speed of the system.

4. Procedure as defined in claim 1, **characterized** in that successive data packets are formed from successive audio frames and that the transfer speed of the data packets transferred as a continuous train is so selected that the transfer speed of an audio frame placed in the data group is the same as the transfer speed of an audio frame transmitted as a continuous stream.

5. Procedure as defined in claim 5, **characterized** in that the entire data group is transmitted in a single transmission frame, in which case the data group is not time-interleaved into several transmission frames.

6. Procedure as defined in claim 1, **characterized** in that a segment number field in the data group header is used as a counter which is incremented by one each time a data group is transmitted.

7. Procedure as defined in claim 1, **characterized** in that an address field in the data group header is used to address a given user group.

8. Procedure as defined in claim 1, **characterized** in that the receiver is informed via mechanisms consistent with the system that the data field of the data group contains audio information.

9. Procedure as defined in claim 1, **characterized** in that the digital broadcasting system is DAB.

10. Procedure as defined in claim 9, **characterized** in that the information that the data field of the data group contains audio information is conveyed in the File Type field of the Information Data Group (IDG).

11. Procedure as defined in claim 9, **characterized** in that the information that the audio is transferred as a file is conveyed via the Fast Information Channel (FIC) by setting the service component type parameter to File Transfer.

12. Procedure as defined in claim 9, **characterized** in that the information that the audio is transferred as an audio stream is conveyed via the Fast Information Channel (FIC) by setting the service component type parameter to DAB Audio Stream.

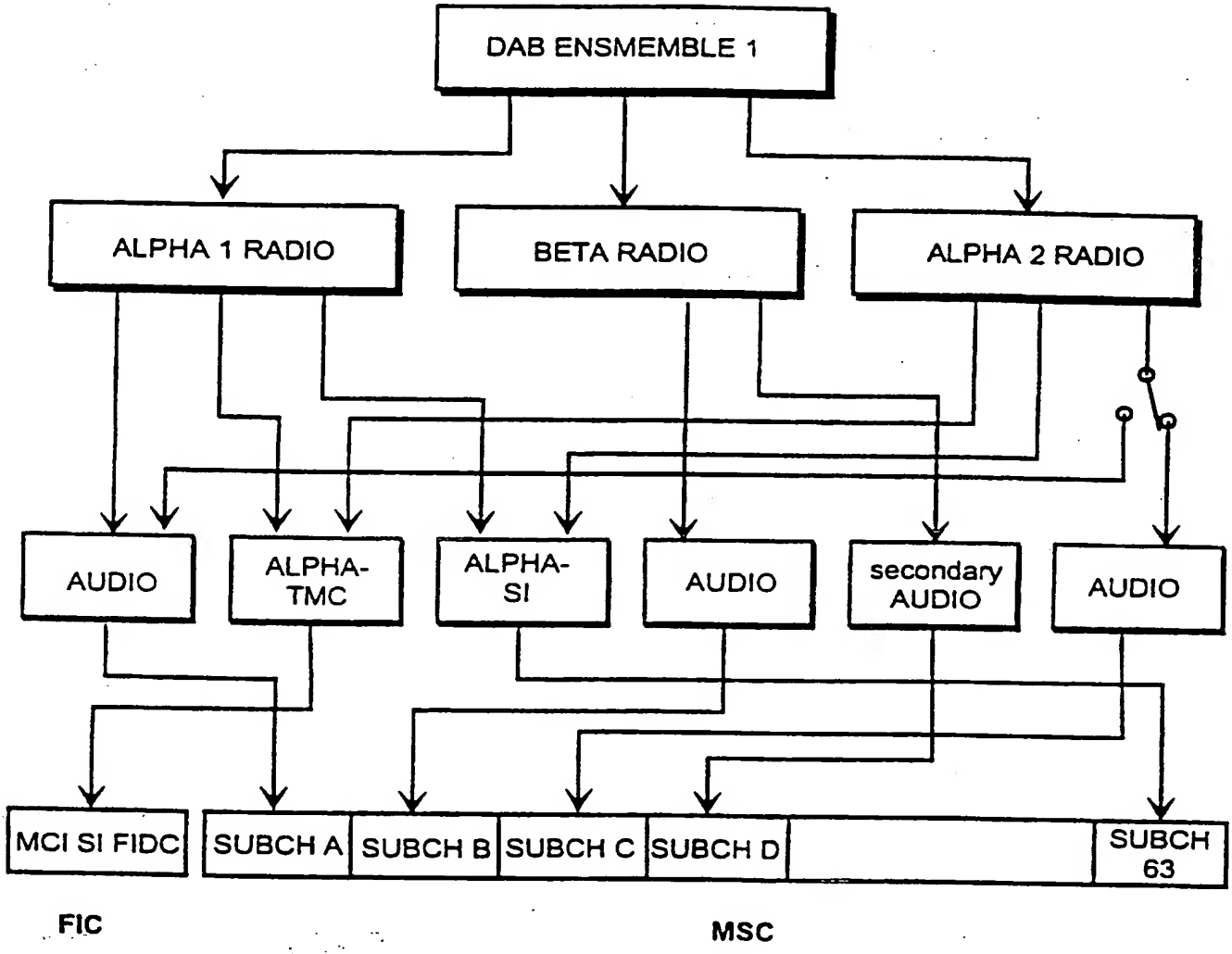

DAB ENSMEMBLE 1
ALPHA 1 RADIO
BETA RADIO
ALPHA 2 RADIO
AUDIO
ALPHA-TMC
ALPHA-SI
AUDIO
secondary AUDIO
AUDIO
MCI SI FIDC
SUBCH A
SUBCH B
SUBCH C
SUBCH D
SUBCH 63
FIC
MSC

Fig. 1

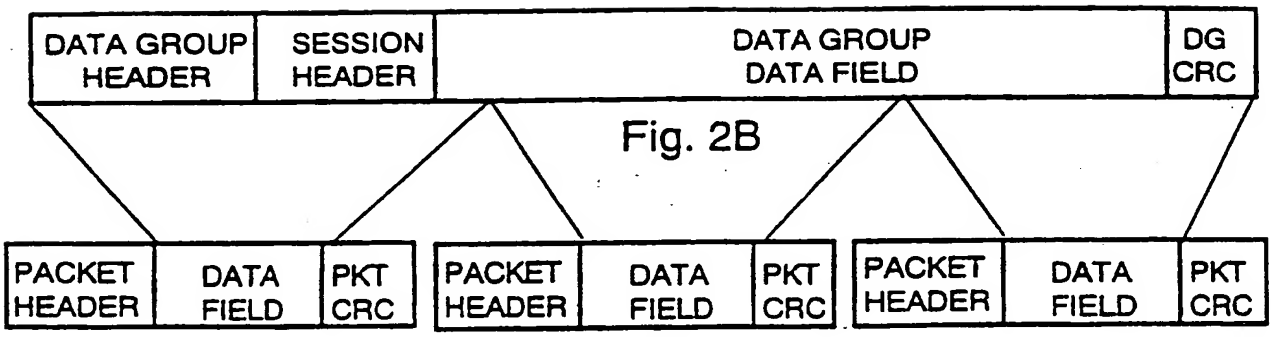


Fig. 2B

Fig. 2A

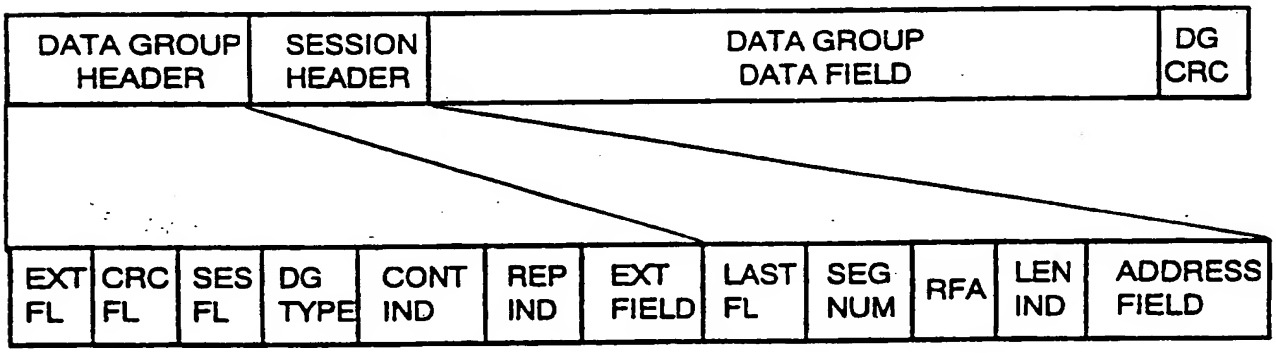


Fig. 3

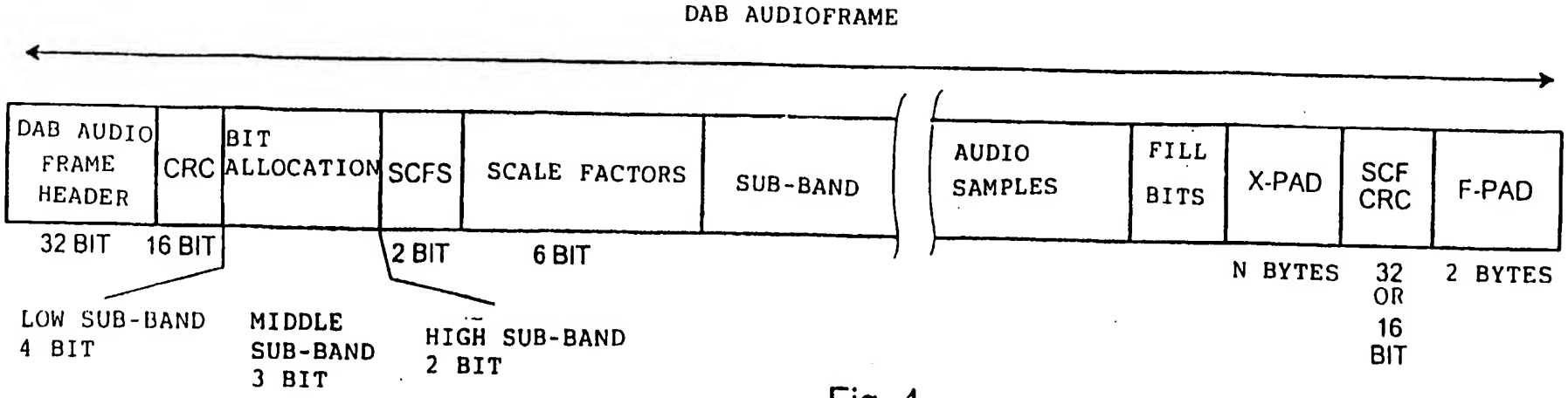
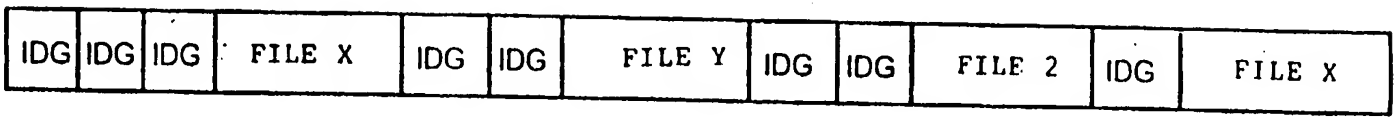


Fig. 4



RELEVANT FILE:	X	Y	Z		Y	Z		Z	X		X
NUMBER OF REPETITIONS:	1	0	0		0	0		0	0		0
NEW FILE INDICATOR:	1	1	1		2	2		3	3		4
FILE DESCRIPTION OFFSET:	1	2	3		1	2		1	2		1

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 96/00595

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04H 1/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04H, H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 4422015 C1 (ROBERT BOSCH GMBH), 3 August 1995 (03.08.95), column 4, line 29 - column 5, line 19 --	1-7
A	FR 2718905 A1 (FRANCE TELECOM), 20 October 1995 (20.10.95), claim 1, abstract --	1-7
A	US 5010549 A (KATOU ET AL), 23 April 1991 (23.04.91), column 1, line 32 - line 68 --	1

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 April 1997	30 -04- 1997
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Christian Rasch Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/FI 96/00595

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 4422015 C1	03/08/95	AU 2611095 A	05/01/96
		CA 2192958 A	21/12/95
		EP 0765547 A	02/04/97
		WO 9534965 A	21/12/95
FR 2718905 A1	20/10/95	CA 2187867 A	26/10/95
		EP 0757878 A	12/02/97
		WO 9528810 A	26/10/95
US 5010549 A	23/04/91	JP 1272247 A	31/10/89

THIS PAGE BLANK (USPTO

This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☑ BLACK BORDERS
- ☑ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☐ FADED TEXT OR DRAWING
- ☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☐ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: _____

IMAGES ARE BEST AVAILABLE COPY.
As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.

THIS PAGE BLANK (USPTO)